Unit Title: DNA Extraction	**Grade Level:** 7
Date Developed/Last Revised: March 4, 2013	**Time Frame:** 60 - 270 minutes
Unit Author(s): Jeanine Nakakura, Leslie Hamasaki	**Primary Content Area:** Life Science/Biology

UNIT DESCRIPTION:

Students will extract DNA from strawberries. As an extension, students can extract DNA from other foods or their cheek cells, and develop a DNA Extraction kit.

Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit):

- All living organisms—from bacteria to plants, animals, and humans—contain DNA
- Genes and chromosomes determine the expressions of inherited traits
- DNA is stored in a cell's nucleus and can be extracted using a few simple steps

Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas):

- Why is DNA so important in biology?
- How can I predict what traits will be passed from one generation to another?
- How are genes and chromosomes important in determining heredity traits?

	BENCHMARKS/STANDARDS/LEARNING GOALS
Science	***Science*** (HCPS III) • SC.7.1.1 Design and safely conduct a scientific investigation to answer a question or test a hypothesis • SC.7.5.2 Describe how an inherited trait can be determined by one or more genes which are found on chromosomes
Technology	***CTE*** (HCPS III) • Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Engineering	***CTE*** (HCPS III) • CTE.7.1.1 Apply the design process through a set of methodical steps for turning ideas into useful and ethical products and systems • CTE 7.1.2 Assess a product or solution for possible modifications

Mathematics	***Math*** (CCSS) • 7.EE.3 Solve real-life and mathematical problems using numerical and algebraic expressions and equations
English Language Arts and Literacy	***Literacy*** (CCSS) 7 (WHST.7.2) Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. • Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. • Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples. • Use appropriate transitions to create cohesion and clarify the relationships among ideas and concepts. • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Establish and maintain a formal style. • Provide a concluding statement or section that follows from and supports the information or explanation presented.
STEM Competencies	Indicator 3.3: Generates new and creative ideas and approaches to developing solutions Indicator 5: The ability to communicate effectively

LESSON SEQUENCE

	Lesson Title/Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame
1	Strawberry DNA Extraction	• Perform a simple DNA extraction from a fruit using household materials • Understand that all living organisms contain DNA • Describe the size, structure, and components of DNA • Understand the importance of DNA	Worksheet or Lab Report, Group discussion	60 minutes
2	Cheek Cell Extraction (extension)	• Extract DNA from human cheek cells using household materials • Collect and preserve DNA	Worksheet or Lab Report (could use Edmodo)	60 minutes
3	DNA Extraction Kit (extension)	• Use the Engineering Design Process to design a kit to extract DNA using household materials • Research similar kits and report on what is currently being sold and how students can make their kits more user-friendly and cost-efficient • Calculate cost of kit to make a profit and put data into a report • Write an instruction guide to explain how to use kit • Create a 1-minute commercial or magazine advertisement to sell kit	Report on current kits sold, cost report, instruction guide, commercial or advertisement	150 minutes

Unit Title: DNA Extraction Lesson Title: Strawberry DNA Extraction Date Developed/Last Revised: 03/4/13 Unit Author(s): Jeanine Nakakura, Leslie Hamasaki	Lesson #: 1 Grade Level: 7 Primary Content Area: Life Science/Biology Time Frame: 50 minutes

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Science (HCPS III):

- SC.7.1.1 Design and safely conduct a scientific investigation to answer a question or test a hypothesis
- SC.7.5.2 Describe how an inherited trait can be determined by one or more genes which are found on chromosomes

Math (CCSS)

- 7.EE.3 Solve real-life and mathematical problems using numerical and algebraic expressions and equations

2A. Criteria- What Students Should Know and Be Able to Do:

Students can:

- Pre-teaching--Students should have basic knowledge of DNA structure and its location in organisms (video, lecture, readings, research)
- Safely conduct a scientific investigation to answer the question: "Is there DNA in strawberries?"
- Observe first-hand that DNA is in the food that they eat
- Experience a simple method of DNA extraction and be able to explain the rationale of each step
- Explain why DNA extraction is important to scientists

2B. Assessment Tools/Evidence:

Formative:

- **Conversations:**
  - Bell ringer questions to begin class--students will be shown 5 objects (or shown a list) and determine whether each contains DNA. Examples of items to use: apple, rock, newspaper, a plastic pen, rubber band, paper clip. Discuss answers in small groups then share out to class. Responses to questions will give teacher an indication of students' preconceptions. (All living things contain DNA)
  - Optional: "Genetics Fun Facts" info sheet attached. Can turn into a True/False Quiz or assign one fact to each student (or group) and have them create a poster to display in class.
  - During lab, ask students to explain what they are doing to check understanding of the purpose of each step.

Observations:

- Pre-assessment quiz (online—see LiveBinder: http://www.livebinders.com/play/play?id=249122 for assessment to select—choose one you like)
- Check to see if students are following lab directions and performing steps safely
- Verbal and/or written feedback on worksheet answers

Summative: (please attach copies of rubrics and/or other assessment tools)

- Product: DNA extracted from strawberry (have students photograph)
- Worksheet completed with accurate answers (have students re-do if not accurate)
- Post-assessment quiz (same as pre-assessment)

3. Learning Experiences (Lesson Plan)

Start with the basic DNA extraction with strawberries. Then use the same procedure with another fruit/food OR do the Cheek Cell DNA Extraction as an extension to incorporate Math, Engineering, and Technology.

Materials:

- Heavy-duty Ziploc bag
- 1 strawberry per group of students
- DNA extraction buffer solution (900 ml water, 50 ml dishwashing detergent, 2 teaspoons salt
- small plastic cup to hold DNA extraction buffer solution
- cheesecloth or coffee filters (approximately 10 cm x 10 cm)
- small funnel
- 50-ml vial/test tube
- glass rod (or bamboo BBQ skewer/wooden chopstick)
- cold ethanol or isopropyl alcohol
- ice

- LiveBinder – Go to www.livebinders.com and search for "DNA Extraction" to find Livebinder with resources on DNA extraction. ***You may also find the DNA extraction LiveBinder by using this link: http://www.livebinders.com/play/play?id=249122

Handouts/Other Resources: (please attach copies)

- Pre/Post-Test (choose one online from "DNA Extraction" LiveBinder)
- Lab Handout/Worksheet for Strawberry DNA Extraction (attached is an example from *The Science Behind Our Food*)

Content Background for instructor:

All living organisms contain DNA. Some fruits are especially suited for DNA extractions due to their multiple sets of chromosomes. Strawberries are octoploid, which means they have 8 copies of each chromosome (human body cells are diploid; they contain two copies of each chromosome).

DNA extraction is a fairly simple procedure that requires a few steps:

- The lysis buffer (detergent) breaks open the cells by destroying the fatty membranes that enclose the cells as well as the nuclei membranes within the cells. DNA is released into the solution. Detergent and the salt also help strip away the proteins that are associated with the DNA molecules.
- DNA is not soluble in alcohol, whereas the other cell parts are. By adding alcohol, DNA precipitates out of the solution and collects at the interface of the alcohol and soap layer. The colder the alcohol, the less soluble the DNA will be in it, so it is best to keep the alcohol in a freezer.

Homework Activity (Optional):

- Genetic Engineering Worksheet—"If I were a Genetic Engineer . . ." (worksheet attached)

Extensions:

- More open-ended Inquiry—have students investigate effects of:
  - types of strawberry (frozen vs. fresh)
  - types of sample (banana, strawberry, cheek cells)
  - type of alcohol (isopropyl vs. ethanol)
  - concentration of alcohol (70% vs. 91%)
  - temperature of alcohol (room temp vs. ice-cold)
  - type of strainer (coffee filter vs. cheesecloth)
  - type of detergent (Dawn vs. Palmolive)

- Engineering
  - developing a kit to extract most DNA at least cost (process engineering)

- Math
  - cost of extraction/unit of DNA
  - mass of DNA extracted/mass of original sample
  - business: sell DNA necklaces

- Technology
  - interactive whiteboard
  - video clips/simulations
  - discuss the technology of DNA extraction ($1000 for your genome, newspaper articles)
  - documentation/user's manual (video/photos/sharing)
  - graphing

- Have students extract DNA from other foods or cheek cell DNA.
  - Cheek Cell DNA Extraction Protocol using Engineering Journal (Teacher Prep Notes, Student handout, and Journal attached)
  - Go to www.livebinders.com and search for "Cheek Cell DNA" for resources or go to:

http://www.livebinders.com/play/play?id=323235
TEACHING & ASSESSMENT (Steps 4, 5, 6, &7) **Completed by teacher after instruction has taken place**
4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

Strawberry DNA Extraction Lesson Plan

This lesson plan is for the extraction of DNA from strawberries. Strawberries are an exceptional fruit to use for this lesson because each individual student is able to complete the process by themselves and strawberries yield more DNA than any other fruit (i.e. banana, kiwi, etc.). Strawberries are octoploid, meaning that they have eight copies of each type of chromosome.

Primary Learning Outcomes
Students will observe first hand that DNA is in the food that they eat. Students will learn the simple method to extract DNA and why each step is necessary due to the complex organization of DNA in cells. Students will learn why it is important for scientist to extract DNA from organisms.

Assessed Georgia Performance Standards

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

SCSh4. Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

SB1. Students will analyze the nature of the relationships between structures and functions in living cells.

SB2. Students will analyze how biological traits are passed on to successive generations.

Background:
Strawberries are soft and easy to pulverize. Strawberries have large genomes; they are octoploid, which means they have eight of each type of chromosome in each cell. Thus, strawberries are an exceptional fruit to use in DNA extraction labs.

The soap helps to dissolve the phospholipid bilayers of the cell membrane and organelles. The salt is used to break up protein chains that bind around the nucleic acids. DNA is not soluble in ethanol. The colder the ethanol, the less soluble the DNA will be in it. Thus make sure to keep the ethanol in the freezer or on ice.

Procedures/Activities
Step: 1 Duration: 10 minutes
Teacher may choose prior to class to prepare the DNA extraction buffer. In a container add 900mL water, then 50mL dishwashing detergent (or 100mL shampoo), and finally 2 teaspoons salt. Slowly invert the bottle to mix the extraction buffer.

Step: 2 Duration: 40 minutes to 60 minutes depending on class cooperation
Lab procedures should be conducted as stated in the *DNA Extraction: Strawberry* lab at the end of this document. Modifications can be made based on the needs of the students. Some classes may decide for each student to add individual components of the extraction buffer to the Ziploc bag (roughly 2 tsp water, 1 tsp soap, 1 pinch salt), while other classes may choose to use the teacher prepared extraction buffer (from Step 1).

When the students add ethanol to their strawberry extract, they will see the fine white strands of DNA precipitate. The DNA will form cotton like fibers that will spool onto the stirring rod/inoculating loop/popsicle stick.

Materials and Equipment
For each student: heavy duty ziploc bag (freezer or storage bag); 1 strawberry; DNA extraction buffer (900mL water, 50mL dishwashing detergent, 2 teaspoons salt); small plastic cup to hold extraction buffer; cheesecloth to fit in small funnel (4" X 4" should be appropriate); small funnel; 50mL vial / test tube; glass rod, inoculating loop, or popsicle stick; cold ethanol, ice

Total Duration
10 minutes teacher prep before class
40-60 minutes in class

Assessment
Lab report and/or discussion questions. Discuss questions as a class to assess the students understanding and ability to communicate scientific concepts. Discuss why each step was needed and how this relates to the organization of genetic material.

Extension
The yield of DNA in this lab may be compared to that of the DNA Banana Extraction lab. Compare ploidy levels and how it may relate to the amount of DNA recovered. Use varying concentrations of ethanol (70-100%) to determine how ethanol concentration qualitatively affects the yield of DNA.

Name_____ Date_____

DNA Extraction: Strawberry

Background: The long, thick fibers of DNA store the information for the functioning of the chemistry of life. DNA is present in every cell of plants and animals. The DNA found in strawberry cells can be extracted using common, everyday materials. We will use an extraction buffer containing salt, to break up protein chains that bind around the nucleic acids, and dish soap to dissolve the lipid (fat) part of the strawberry cell wall and nuclear membrane. This extraction buffer will help provide us access to the DNA inside the cells.

Pre-lab questions:

1. What do you think the DNA will look like?

2. Where is DNA found?

Materials:

heavy duty ziploc bag
1 strawberry
10 mL DNA extraction buffer (soapy, salty water)
cheesecloth
funnel
50mL vial / test tube
glass rod, inoculating loop, or popsicle stick
20 mL ethanol

Procedure:

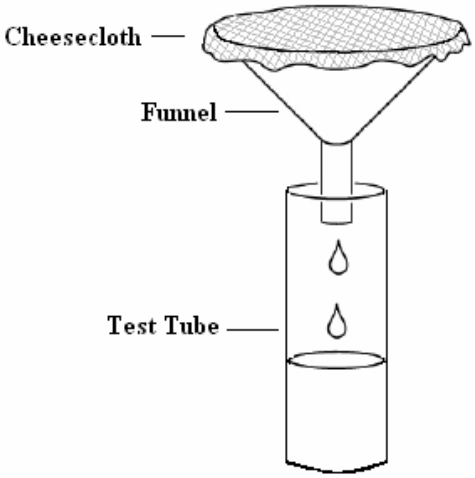
1. Place one strawberry in a Ziploc bag.

2. Smash/grind up the strawberry using your fist and fingers for 2 minutes. *Careful not to break the bag!!*

3. Add the provided 10mL of extraction buffer (salt and soap solution) to the bag.

4. Kneed/mush the strawberry in the bag again for 1 minute.

5. Assemble your filtration apparatus as shown to the right.



6. Pour the strawberry slurry into the filtration apparatus and let it drip directly into your test tube.

7. Slowly pour cold ethanol into the tube. OBSERVE ☺

8. Dip the loop or glass rod into the tube where the strawberry extract and ethanol layers come into contact with each other. OBSERVE ☺

Conclusions and Analysis

1. It is important that you understand the steps in the extraction procedure and why each step was necessary. Each step in the procedure aided in isolating the DNA from other cellular materials. Match the procedure with its function:

PROCEDURE	FUNCTION
A. Filter strawberry slurry through cheesecloth	___ To precipitate DNA from solution
B. Mush strawberry with salty/soapy solution	___ Separate components of the cell
C. Initial smashing and grinding of strawberry	___ Break open the cells
D. Addition of ethanol to filtered extract	___ Break up proteins and dissolve cell membranes

2. What did the DNA look like? Relate what you know about the chemical structure of DNA to what you observed today.

3. Explain what happened in the final step when you added ethanol to your strawberry extract. (*Hint*: *DNA is soluble in water, but not in ethanol*)

4. A person cannot see a single cotton thread 100 feet away, but if you wound thousands of threads together into a rope, it would be visible much further away. Is this statement analogous to our DNA extraction? Explain.

5. Why is it important for scientists to be able to remove DNA from an organism? List two reasons.

6. Is there DNA in your food? _____ How do you know?

Name _____ Period _____ Date _____

Engineering Journal

ASK: What questions do you have to clarify the criteria or constraints of the project? What prior knowledge can you tap?	**IMAGINE:** Brainstorm possible solutions. (You may list, describe, draw…)
PLAN: Choose one idea and draw a prototype. Include a description/explanation, if desired.	**CREATE:** Follow your plan. Modify as necessary to make it work. Explain any modifications here.
EXPERIMENT: Test your prototype. Collect data and record it here.	**IMPROVE:** Analyze data. Repeat the engineering design process to optimize the product.

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Genetics Fun Facts

- It takes about eight hours for one of your cells to completely copy its DNA.
- The human DNA code is made up of about three thousand million A,T, C, and Gs on each side of the DNA strand.
- If you were to start reciting the order of the ATCGs in your DNA tomorrow morning, at a rate of 100 each minute, 57 years would pass before you reached the end (provided that you did not stop to eat, drink, sleep, use the bathroom etc.).
- If you were to stretch out the DNA from those 46 chromosomes in one cell and lay it end to end, it would be over 2 yards in length.
- If the total DNA in one person were laid in a straight line, it would stretch to the sun and back over 30 times (it's 93 million miles from here to the sun).
- You could fit one thousand nuclei across the period at the end of this sentence.
- You could fit one million threads of DNA across the period at the end of this sentence.
- If the genome was a book, it would be the equivalent of 800 dictionaries. It would take a person typing 60 words per minute, eight hours a day, around 50 years to type the human genome. You would need 3 gigabytes of storage space on a computer to hold all of this. Yet all this information is contained inside the microscopic nucleus of a cell so tiny that it could easily fit on the head of a pin!

Organism	**# of genes**
Yeast	6,000
Drosophila	13,000
Nematode	18,000
Flowering plant	26,000
Human	30,000

Organism	**# of chromosomes**
Human	46
Gorilla	48
Dog	78
Dove	16
Butterflies	380 (!)
Bananas	66

- Humans are 99.9% genetically identical – only 0.1% of our genetic make-up differs.
- Our genes are remarkably similar to those of other life forms. For example, we share 98% of our genes with chimpanzees, 90% with mice, 85% with zebra fish, 21% with worms, and 7% with a simple bacterium such as E. coli.
- Less than 2% of the total DNA carries instructions to make proteins. The rest is misleadingly called 'junk' DNA, because it is a hodge-podge of sequences that does not seem to code for anything.

Sources: www.genomecanada.ca/en/info/dna/know.aspx
seplessons.ucsf.edu/files/Genetics%20Fun%20Facts.doc

Name_____ **Date**_____ **Period**_____

If I Were a Genetic Engineer . . .

I would combine the DNA of:

Name of 1st organism: _____	Name of 2nd organism: _____
Drawing of first organism:	Drawing of second organism:

Drawing of genetically-engineered organism: (Describe your organism on the back of this paper.)

Describe your genetically-engineered organism with a minimum of 5 sentences (number your sentences from 1 to 5). Make sure you answer the questions in the checklist below to receive full credit for this assignment.

Answer the questions below completely (incomplete answers will receive partial credit).

_____ What is genetic engineering? (2 points)

_____ What two organisms did you combine? (2 points)

_____ Why did you combine these two organisms? (2 points)

_____ What traits does your genetically-engineered organism have? (2 points)

_____ What is one advantage and one disadvantage to your genetically-engineered organism? (2 points)

_____ **/10 TOTAL POINTS**

Write your paragraph in the box below.

DNA -- Teacher Preparation Notes

by Dr. Jennifer Doherty and Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, 2011[1]

Teaching Points

- DNA is a nucleic acid made of two strands of nucleotides wound together in a spiral called a double helix.
- Each nucleotide is composed of a sugar molecule known as deoxyribose, a phosphate group, and one of four different nitrogenous bases: adenine (**A**), thymine (**T**), guanine (**G**), or cytosine (**C**).
- The phosphate and sugar parts of the nucleotides form the backbone of each strand in the DNA double helix.
- The bases extend toward the center of the double helix, and each base in one strand is matched with a complementary base in the other strand, in accord with the base-pairing rules: **A** pairs with **T** and **G** pairs with **C**.
- These characteristics are the same for the DNA of all organisms. The DNA of different organisms differs in the sequence of nucleotides, and these differences in nucleotide sequence are responsible for the genetic differences between different organisms.
- DNA replication produces two new DNA molecules that are identical to the original DNA molecule, so each of the new DNA molecules carries the same genetic information as the original DNA molecule.
- During DNA replication, the two strands of the original DNA double helix are separated and each old strand is used as a template to form a new DNA strand. The enzyme DNA polymerase adds nucleotides one-at-a-time, using the base-pairing rules to match each nucleotide in the old DNA strand with a complementary nucleotide in the new DNA strand. Thus, each new DNA double helix contains one strand from the original DNA molecule, together with a newly synthesized matching DNA strand.
- In eukaryotic cells, each chromosome consists of DNA wrapped around proteins. The chromosomes are contained in the nucleus inside a nuclear membrane.

Equipment and Supplies:

Sports Drink like Gatorade (10 mL per student)
Liquid dish soap (0.25 mL per student)
Meat Tenderizer (a pinch per student)
70-95% isopropyl or ethyl alcohol (4 mL per student)
String for necklace (2.5 ft per student)
3 oz. Dixie cups (1 per student)
Tub of ice, freezer, or refrigerator (1)
Tub for dirty test tubes (1)
Bleach (1% bleach solution to sterilize test tubes)
Small test tubes (tubes need to hold a minimum of 15 mL) (1 per student)
Test tube rack (1 per group)
0.5-1.5 mL fliptop microcentrifuge tubes (1 per student)
Transfer pipettes (1 per group)
Gloves (1 per student)

Preparations

Before Class:

1. Cut string into 2.5 ft pieces.

[1] These teacher preparation notes, the related student handout and other activities for teaching biology are available at http://serendip.brynmawr.edu/sci_edu/waldron/.

2. Set up a bucket of ice to keep alcohol cold or put alcohol in the freezer/refrigerator until needed.
3. Pour a small cup sports drink for each student.

During class:

1. Distribute cups of sports drink to each student. It is important for each student to swish the drink in his or her mouth vigorously for at least a minute in order to obtain enough cheek cells.
2. Distribute a test tube rack with one test tube per student to each group. Distribute one glove to each student. Pass out the soap and meat tenderizer. Alternatively, you can have a station somewhere in the classroom where the students can access the soap, etc.
3. After at least 10 minutes (when the students have completed the "DNA structure" portion of the student handout), pass out the cold alcohol and pipettes.
4. After 10 minutes (when the students have completed the "DNA replication" portion of the student handout), distribute one microcentrifuge tube and piece of string to each student.
5. Assist students' transfer of their DNA to their microcentrifuge tubes using the pipettes. It helps to twirl the DNA around the end of the pipette to get a large wad together before sucking the DNA into the pipette. Warn the students to be gentle while pipetting so they do not damage the fragile strands of DNA. Inexperienced pipetters have a tendency to blow air into the liquid and suck up and expel the DNA several times in the test tube before transferring it to the microcentrifuge tube; this tends to break the DNA strands.
6. Put on a pair of gloves and collect the test tube racks from the students. Pour test tube contents out down the sink, rinse the test tubes, and place them in a tub of 1% bleach solution for 10 minutes to sterilize them for the next class. (You may want to assign this job to a student).
7. Remove test tubes from bleach water and invert them in the racks to dry for the next class.
8. Return the alcohol to the ice bucket or freezer/refrigerator.

Instructional Suggestions and Additional Information

As background for this activity, students should know that DNA is the genetic material and DNA is contained in chromosomes inside the nucleus inside a cell. "Understanding the Functions of Proteins and DNA" (available at http://serendip.brynmawr.edu/exchange/bioactivities/proteins) provides a suggested sequence of activities for introducing students to DNA as the genetic material.

The proteases in the meat tenderizer not only digest histones (the proteins that DNA wraps around), but also break down enzymes in cells which could digest the DNA.

Cold alcohol helps to precipitate the DNA molecules by reducing the temperature and dehydrating the salty soapy solution of DNA immediately under the alcohol layer. The high salt concentration (from the sports drink and meat tenderizer) is also important since DNA molecules are negatively charged and the salt neutralizes the repulsion among the negatively charged strands of DNA and allows the DNA to clump together.

This activity combines hands-on extraction of DNA from human cheek cells with questions on DNA structure and replication that students answer during the wait times for DNA extraction. For question 3 on page 5 you may want to substitute an alternative hands-on simulation version in which students use nucleotide diagram pieces and tape to carry out DNA replication; templates for the nucleotide diagram pieces are provided in the Teacher Notes available at http://serendip.brynmawr.edu/exchange/bioactivities/DNA.

If you prefer to extract DNA from samples other than human cheek cells, we recommend the procedure for extracting DNA from split peas available at http://learn.genetics.utah.edu/content/labs/extraction/howto/. The directions for preparing the mixture of peas, salt and detergent to pour in test tubes will produce enough mixture for ~24 15 mL test tubes; then your students can carry out the steps of adding enzymes and alcohol and pulling out the DNA. In our experience you may want to use the blender for slightly longer than 15 seconds, you should not be surprised when you have a lot of leftover peas after the straining step, you can use somewhat less alcohol than suggested, and it seems to work best if the alcohol is cold. Alternatively, you can use the directions for extracting DNA from bananas (available at http://www2.le.ac.uk/departments/genetics/vgec (search for Go Bananas)) or wheat germ (available at http://learn.genetics.utah.edu/archive/wheatgerm/index.html).

Any of these extraction procedures can be used together with our discussion/worksheet activity about DNA structure and replication (available at http://serendip.brynmawr.edu/exchange/bioactivities/DNA). Frequently Asked Questions, including answers to questions about Trouble-shooting, Understanding the Science Behind the Protocol, Comparing the DNA Extracted from Different Cell Types, and Real-life Applications of the Science of DNA Extraction are available at http://learn.genetics.utah.edu/content/labs/extraction/howto/faq.html. Helpful figures for explaining how detergents break down lipids are available at http://learn.genetics.utah.edu/archive/wheatgerm/background.html. A DNA Extraction Virtual Lab is available at http://learn.genetics.utah.edu/units/activities/extraction/ .

To help students understand why accurate replication of the sequence of nucleotides in DNA is so important, you may want to use all or part of the following diagram in your discussion of question 3 on the top of page 5 of the Student Handout.

nucleotide sequence in the DNA of a gene

→ nucleotide sequence in messenger RNA (mRNA)
(transcription)

→ amino acid sequence in a protein
(translation)

→ structure and function of the protein
(e.g. normal hemoglobin vs. sickle cell hemoglobin)

→ person's characteristics or traits
(e.g. normal health vs. sickle cell anemia)

Our DNA activity teaches students about DNA structure and replication, but includes only minimal discussion of the function of DNA. We recommend that you follow this DNA activity with our activity "From Gene to Protein -- Transcription and Translation" to teach students about the function of DNA. This hands-on simulation activity (available at http://serendip.brynmawr.edu/sci_edu/waldron/#trans) helps students understand how the sequence of nucleotides in a gene specifies the sequence of amino acids in a protein which in turn determines the structure and function of the protein and results in characteristics such as sickle cell anemia.

One important point that is not mentioned in our Student Handout is that, during actual DNA replication, sometimes mistakes are made and the wrong nucleotide is added to the new strand of

DNA. DNA polymerase can "proofread" each new double helix DNA strand for mistakes and backtrack to fix any mistakes it finds. To fix a mistake, DNA polymerase removes the incorrectly paired nucleotide and replaces it with the correct one. If a mistake is made and not found, the mistake can become permanent. Then, any daughter cells will have this same change in the DNA molecule. These changes are called point mutations because they change the genetic code at one point, i.e. one nucleotide. Some point mutations result in significant effects, such as the genetic disease, sickle cell anemia.

To ensure student understanding of the basic process of DNA replication, this activity ignores many of the complexities observed in actual DNA replication. Also, although the same basic DNA double helix structure is observed in all living organisms (as emphasized in this activity), the structure of chromosomes differs between eukaryotes and prokaryotes. For more information on these topics, see a college textbook for biology majors such as Campbell, Reece, et al., Biology; Freeman, Biological Science; or Raven et al., Biology.

Extracting DNA From Your Cells

Adapted from: Hands on Activities for Teaching Biology to High School or Middle School Students. Molecular Biology-DNA. Drs. Ingrid Waldron and Jennifer Doherty. http://serendip.brynmawr.edu/sci_edu/waldron/#dna

Today you will extract DNA from some of your cells and learn more about DNA.

Essential questions:
Why is DNA so important in biology?
What is the function of DNA?

Bellwork:
Put the correct answer to the pretest question here using pictures to explain the terms from big to small.
(Go to "Cheek Cell DNA" LiveBinder at www.livebinders.com for Powerpoint to accompany lesson)

Background Information:

Cells from the lining of your mouth come loose easily, so you will be able to collect cells containing your DNA by swishing a liquid around in your mouth.

To extract DNA from your cells, you will need to separate the DNA from the other types of biological molecules in your cells. You will be using the same basic steps that biologists use when they extract DNA (e.g. to clone DNA or to make a DNA fingerprint). You will follow these 3 easy steps to extract the DNA:

Detergent
e**N**zymes (meat tenderizer)
Alcohol

Purpose: To extract DNA from your cheek cells to create a necklace to wear.

Materials:
Sports drink like Gatorade (10 mL per student)
Liquid dish soap (0.25 mL per student)
Meat tenderizer (a pinch per student)
70-95% isopropyl or ethyl alcohol (4 mL per student)
String for necklace (2.5 ft per student)
3 oz. Dixie cups (1 per student)
Tub of ice, freezer, or refrigerator (1)
Tub for dirty test tubes (1)
Bleach (1% bleach solution to sterilize test tubes)
Small test tubes (tubes need to hold a minimum of 15 mL) (1 per student)
Test tube rack (1 per group)
0.5-1.5 mL fliptop microcentrifuge tubes (1 per student)
Transfer pipettes or straws (1 per group)
Gloves (1 per student)

Student Instructions

Getting Your Sample of Cells
Obtain a cup with sports drink. You will need to get thousands of your cheek cells in the sports drink in order to extract enough DNA to see. Therefore you should swish the sports drink around in your mouth vigorously for at least one minute. Then spit the drink back into the cup.

Step 1: Detergent
Add a small amount of detergent to a test tube (about 0.25 mL). Put a glove on the hand you will use to hold your test tube, not the hand you will use to pour. Now carefully pour the drink containing your cheek cells into the test tube with detergent until the tube is **half full**.

Why am I adding detergent?
To get the DNA out of your cheek cells you need to break open both the cell membranes and the nuclear membranes. Cell membranes and nuclear membranes consist primarily of lipids. Dishwashing detergent, like all soaps, breaks up clumps of lipids. This is why you use detergents to remove fats (which are lipids) from dirty dishes. Adding the detergent to you cheek cell solution will break open the cell membranes and nuclear membranes and release your DNA into the solution.

Step 2: Enzymes
Add a pinch of enzyme (meat tenderizer) to your test tube. With your gloved thumb (or palm) covering the top of the test tube, gently invert the tube five times to mix. Remove your glove and throw it in the garbage. Let the mixture sit for at least 10 minutes.

Why am I adding enzymes?
The nucleus of each of your cells contains multiple long strands of DNA with all the instructions to make your entire body. If you stretched out the DNA found in one of your cells, it would be 2-3 meters long. To fit all of this DNA inside a tiny cell nucleus, the DNA is wrapped tightly around proteins. The enzyme in meat tenderizer is a protease, which is an enzyme that cuts proteins into small pieces. As this enzyme cuts up the proteins, the DNA will unwind and separate from the proteins.

Step 3: Alcohol
Using a pipette, slowly add cold rubbing alcohol into the test tube; let the alcohol run down the side of the test tube so it forms a layer on top of the soapy liquid. Add alcohol until you have about 2 cm of alcohol in the tube. Alcohol is less dense than water, so it floats on top. **Do not mix or bump the test tube for 10 minutes.** DNA molecules will clump together where the soapy water below meets the cold alcohol above, and you will be able to see these clumps of DNA as white strands.

Why am I adding alcohol?
The cold alcohol reduces the solubility of DNA. When cold alcohol is poured on top of the solution, the DNA precipitates out into the alcohol layer, while the lipids and proteins stay in the solution.

Making Your Necklace
By now your DNA should be visible as clumps of white strands floating in the alcohol layer. There may be air bubbles attached to the strands.

Use a pipette to suck up your DNA from the test tube and transfer it to the small capped tube. Fill the small capped tube the rest of the way with alcohol. Close the cap of the tube around a piece of string. Now you have a necklace with your very own DNA!

Your assignment (Performance Task):
Create a kit to extract cheek cell DNA to make a necklace. Your kit should contain a user's manual with background information on DNA and how to use the kit. The kit should also discuss the purpose of each material and emphasize safety procedures. Keep documentation of how you improved the original protocol to extract cheek cell DNA and the price you will charge for this kit to make a 25% profit. You must also keep an engineering design process notebook with the following steps: Ask, Imagine, Plan, Create, Experiment, Improve.